

Long-term mass changes over Greenland derived from high-low satellite-to-satellite tracking

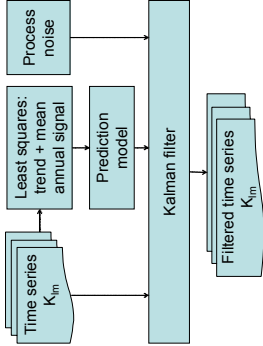
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Introduction:

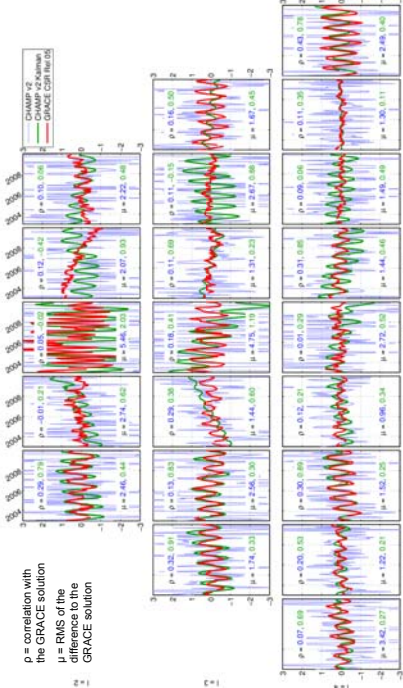
Time variable gravity field (TVG) solutions from high-low satellite-to-satellite tracking (hl-SST) missions have been of very limited use to geophysical and environmental investigations mainly due to its high noise level. We applied a thorough reprocessing strategy to CHAMP data and developed a dedicated Kalman filter which allows for better estimates of the TVG. We demonstrate that the quality of the new solutions is sufficient to derive long-term trends and annual amplitudes of mass change over Greenland.

Reprocessing strategy:

Two important steps allow for better estimates of the TVG. First, a thorough GPS reprocessing of the CHAMP data yielded a gain of one order of magnitude in the precision of monthly gravity field solutions. A Kalman filter is then used to further reduce noise in the time series of the spherical harmonic coefficients. The prediction model for the Kalman filter is derived by a least-squares adjustment from the original time series. A random walk is introduced as process noise allowing for variations w.r.t. the prediction model. The filtering is repeatedly applied with different instances of the process noise (ensemble Kalman approach) and solutions are averaged.

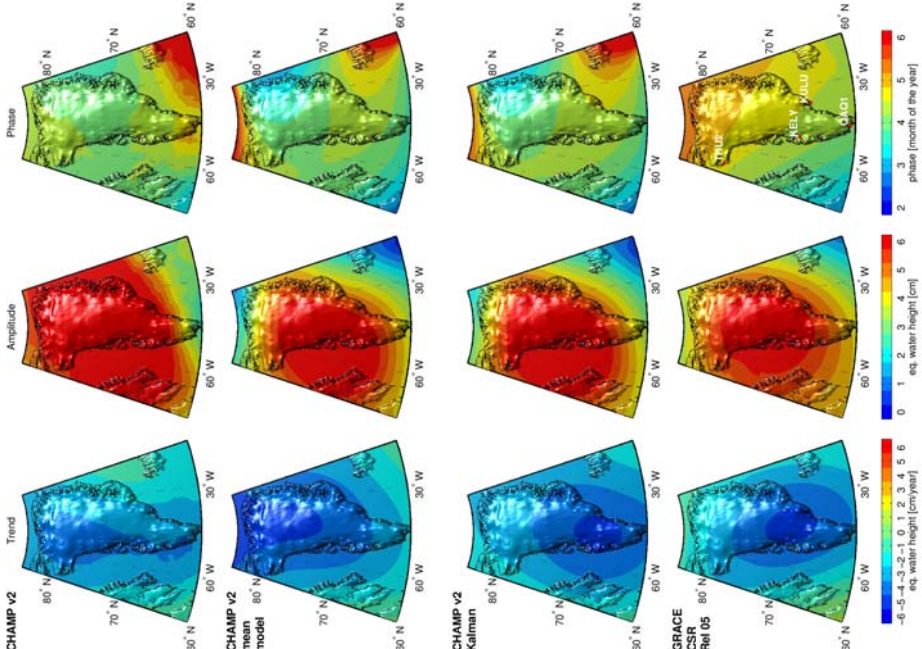


Time series of filtered spherical harmonic coefficients



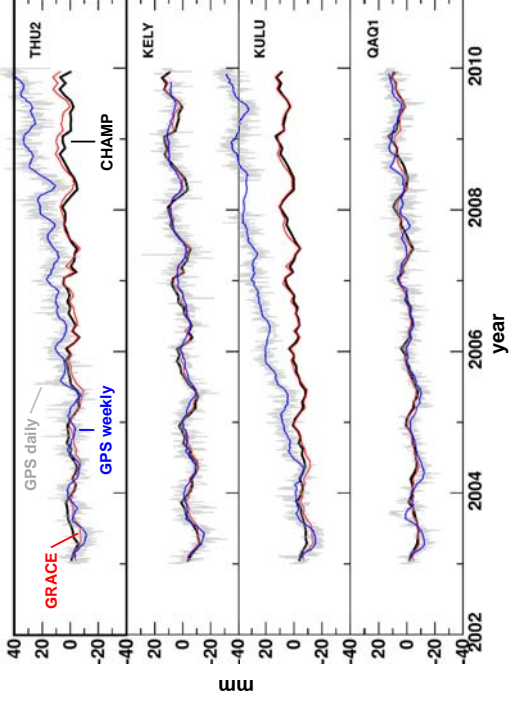
Time variable gravity field

The Kalman approach yields a considerable noise reduction in the time series of the spherical harmonic coefficients. The estimation of the trend, amplitude and phase of the annual signal are consistently improved. Most gain is achieved in the trend estimate. Nevertheless, solutions are limited to the long-wavelength features due to the reduced sensitivity of hl-SST. Subsequent results are filtered with a Gaussian filter of 1000km.



GPS Loading analysis

The filtered CHAMP solution is converted into estimates of surface height changes and compared to GRACE and daily and weekly GPS estimates for four GPS stations on Greenland. Here, a Gaussian filter of 500km has been applied to all data sets. In all cases the CHAMP estimates compare extremely well with the one of GRACE. For Kangerlussuaq (KELY) and Qaortoq (QAO1) the estimates agree very well with GPS. For Thule (THU2) and Kulusuk (KULU), deviations between the satellite solutions and GPS can be observed. Both are caused by local phenomena which are invisible to the satellites. At KULU the GPS time series is affected by the mass loss of the nearby Helheim Glacier. For THU2 the reason is still unclear. Nevertheless, the results demonstrate the high quality of the hl-SST time variable gravity field solutions.



Conclusions

- Due to the improved processing strategy it is possible to derive mass estimates for Greenland from high-low satellite-to-satellite tracking mission (demonstrated here for CHAMP).
- These time variable gravity field solutions are now a viable source of information for geophysical and environmental investigations.
- Using GOCE and SWARM observations, hl-SST estimates can also serve as a gap filler in case GRACE stops operating before the launch of GRACE Follow-On.